the air guns in each such cluster also be aligned in substantially parallel planes; *i.e.*, planes parallel to plane **B-B**. Of course, the ports of successive air gun clusters need not be in identical planes because of differences in air gun sizes and configurations. In addition to a generally uniform depth, the longitudinal axes **A-A** of the air guns **102a-d** are aligned substantially orthogonal to the direction of towing **T**. In a preferred arrangement, the axes **A-A** are also parallel with the horizontal axis **H-H**. From the plan or top view of **Figure 1A**, it can be seen that air guns **102a-d** are thereby placed in a side-by-side or tandem-like configuration. In an alternate embodiment shown in **Figure 1C**, the longitudinal axes **A-A** of the air guns **102** are aligned substantially orthogonal to the direction of towing **T** and also substantially orthogonal to the horizontal axis **H-H**. When this alternate embodiment is used, the air gun tail **103b** is directed upwards and the air gun head **103a** is directed generally downward. In this alternate embodiment, the plane along which the air gun ports **103c** are aligned will be parallel to the water surface **110**. It should be appreciated that these side-by-side configurations enable a more dense packing of the air guns **102a-d** as compared, for example, to a configuration wherein the air guns are laid end-to-end. Referring now to **Figure 1B**, the air guns **102** are positioned at a pre-defined depth **D** below the water surface **110**. As is known, the air guns **102** must be submerged in order to produce an effective air bubble. Often, depth **D** is approximately one meter or greater. The depth **D**, however, can be greater or less depending on the particular application. It would be apparent to one skilled in the art as to the proper depth **D** at which the air guns **102** should be submerged for a given application.

concl A2

In the Claims

Please add the following new claims:

A3

45. A towable marine acoustic source apparatus, comprising:

an array including at least a first cluster, said first cluster including at least two acoustic sources each having a longitudinal axis, said first cluster being defined by a spatial relationship wherein:

(a) said acoustic sources are disposed at a substantially common depth,

(b) each said longitudinal axis of said sources are substantially orthogonal to a pre-determined direction of towing; and

(c) each said longitudinal axis of said sources are substantially orthogonal to a

horizontal plane.

46. The apparatus of claim (45) wherein said first cluster comprises at least two air guns.

47. The apparatus of claim (46) wherein said air guns each have a connection interface adapted for receiving one of gas, electrical power, said connection interfaces being oriented in substantially the same direction.

48. The apparatus of claim (46) wherein said air guns each have a pre-defined center, said air guns having a center-to-center spacing is no greater than about D_s, where D_s is calculated by the equation: $D_s = .62 \cdot V^{1/3}$ meters, where V is a volume of a largest operative acoustic source in cubic inches.

49.The apparatus of claim (46) wherein said air guns each have a pre-defined center, said air guns having a center-to-center spacing that is no less than $(D_c - (D_c)(50\%))$, where D_c is calculated by the equation: $D_c = 2\left(\frac{3}{4\pi}\frac{P}{P_o}V\right)^{1/3}$, where P is an acoustical source absolute pressure, P_o is an ambient absolute pressure, and V is a volume of said acoustical source in said cluster.

cont A3

50. A method of performing a marine seismic survey, comprising:

(a) towing a plurality of acoustic sources each having a longitudinal axis; and

(b) providing an array having at least a first cluster, the first cluster being formed by:

(i) positioning the acoustic sources along a plane generally parallel with a water surface; and

(ii) aligning the longitudinal axis of each acoustic source substantially orthogonal to a pre-determined direction of towing; and

(iii) aligning the longitudinal axis of each acoustic source substantially orthogonal to the water surface.

51. The method of claim (50) wherein the air guns each have a pre-defined center, the air guns having a center-to-center spacing is no greater than about D_s , where D_s is calculated by the equation: $D_s = .62 \cdot V^{1/3}$ meters, where V is a volume of a largest operative acoustic source in cubic inches.

52. The method of claim (50) further comprising:

defining a center for each air gun; and

maintaining a center-to-center spacing no less than (D_c – (D_c)(50%)), where D_c is calculated by the equation: $D_c = 2\left(\frac{3}{4\pi}\frac{P}{P_o}V\right)^{1/3}$, where P is an acoustical source absolute pressure, P_o is an ambient absolute pressure, and V is a volume of the air gun in the cluster.

53. The method of claim (50) further comprising forming a second cluster of at least two air guns each having ports; positioning the second cluster adjacent the first cluster; and aligning the ports of the second cluster air guns along a second plane that is substantially parallel with the first plane.

Ex A 3

54. A marine acoustic source system, comprising:

(a) an acoustic array including at least one cluster, said cluster having at least two acoustic sources, said sources each having a longitudinal axis, said cluster being defined by a spatial relationship wherein:

(i) said acoustic sources are aligned in a plane generally parallel with the water surface;

(ii) each said longitudinal axis of said sources are substantially orthogonal to a pre-determined direction of towing;

(iii) each said longitudinal axis of said sources are substantially orthogonal to the water surface;

(b) a supply line operatively connected to said acoustic array, said supply line adapted to convey one of power and data to said acoustic array;

(c) a termination matable with said supply line;

cancel A3

(d) a tow line connected to said termination for towing said array through water; and

(e) a service vessel to which said tow line is attached.

MARKED-UP VERSION SHOWING CHANGES MADE TO THE SPECIFICATION

In the Drawing:

Please add new Figure 1C. Please amend Figure 1A as noted in red.

In the Specification:

Please replace the paragraph beginning at page 7, line 1 with the following:

For a detailed description of an embodiment of the invention, reference will now be made to the accompanying drawings wherein:

Figure 1A schematically illustrates a plan view of a preferred air gun cluster made in accordance with the present invention;

Figure 1B schematically an elevation view of a preferred acoustic source system deployed in water;

<u>**Figure 1C** schematically an elevation view of a preferred air gun cluster wherein the longitudinal axis of the air guns are orthogonal to the direction of towing and the horizontal axis;</u>

Figure 2 schematically illustrates a plan view of a preferred seismic acoustic source system made in accordance with the present invention;

Figure 3 illustrates a sectional view of a preferred protective tube made in accordance with the present invention;

Figure 4 illustrates an elevation view of a preferred coupling and connectors made in accordance with the present invention;

Figure 5A graphically illustrates a relative spacing of a non-cluster type conventional acoustic source array;

Figure 5B graphically illustrates the calculated performance of the non-cluster type conventional acoustic source array;

Figure 5C graphically illustrates the available frequency range of the non-cluster type conventional acoustic source array;

Figure 5D graphically illustrates an exemplary spacing of a clustered acoustic source array that employs the teachings of the present invention;

Figure 5E graphically illustrates the calculated performance of a clustered acoustic

source array that employs the teachings of the present invention;

Figure 5F graphically illustrates the available frequency range of a clustered acoustic source array that employs the teachings of the present invention; and

Figure 6 schematically illustrates an exemplary acoustic source system deployed in a marine environment.

Please replace the paragraph beginning at page 12, line 16 with the following:

Referring now to **Figures 1A** and **1B**, the air guns **102a-d** of the air gun cluster **100** have a preferred spatial relationship relative to the water surface **110**, the direction of towing **T**, and each other. The air guns **102a-d** are arranged generally along a horizontal plane **H-H** that is substantially parallel with the water surface **110**. By maintaining the air guns **102a-d** at a substantially common depth, the forces associated with air gun activation will be more symmetric than the forces associated with air guns positioned at different depths. It will be understood that the term "water surface" refers to a nominal condition wherein the water surface is relatively flat and unperturbed by, for example, inclement weather. Accordingly, the "water surface" or "a plane parallel to the water surface" is used synonymously with the term "horizontal plane." Further, the ports **103c** of the air guns are aligned along substantially the same plane **B-B**. Plane **B-B** is substantially vertical (*i.e.*, perpendicular to the water surface). This alignment of the ports **103c** promotes the coalescence of the air bubbles created by the high-pressure fluid (*e.g.*, air) discharged from the ports **103c**. Where more than one cluster is used, it is also preferred that the ports of the air guns in each such cluster also be aligned in substantially parallel planes; *i.e.*, planes parallel to plane **B-B**. Of course, the ports of successive air gun clusters need not be in identical planes because of differences in air gun sizes and configurations. In addition to a generally uniform depth, the longitudinal axes **A-A** of the air guns **102a-d** are aligned substantially orthogonal to the direction of towing **T**. In a preferred arrangement, the axes **A-A** are also parallel with the horizontal axis **H-H**. From the plan or top view of **Figure 1A**, it can be seen that air guns **102a-d** are thereby placed in a side-by-side or tandem-like configuration. In an alternate embodiment [that is not] shown <u>in **Figure 1C**</u>, the longitudinal axes <u>**A-A**</u> of the air guns <u>**102**</u> are aligned substantially orthogonal to the direction of towing <u>**T**</u> and also substantially orthogonal to the horizontal axis <u>**H-H**</u>. When this alternate

embodiment is used, the air gun tail **103b** [(**Fig. 1A)**] is directed upwards and the air gun head **103a** [(**Fig. 1A)**] is directed generally downward. In this alternate embodiment, the plane along which the air gun ports **<u>103c</u>** are aligned [(corresponding to plane **B-B** in **Figure 1A**)] will be parallel to the water surface **<u>110</u>**. It should be appreciated that these side-by-side configurations enable a more dense packing of the air guns **102a-d** as compared, for example, to a configuration wherein the air guns are laid end-to-end. Referring now to **Figure 1B**, the air guns **102** are positioned at a pre-defined depth **D** below the water surface **110**. As is known, the air guns **102** must be submerged in order to produce an effective air bubble. Often, depth **D** is approximately one meter or greater. The depth **D**, however, can be greater or less depending on the particular application. It would be apparent to one skilled in the art as to the proper depth **D** at which the air guns **102** should be submerged for a given application.